Section 18 Application – Sulfoxaflor (Transform WG Insecticide)
Tennessee Cotton

Submitted by the Tennessee Department of Agriculture

Type of Exemption - Tennessee Section 18; Specific Exemption Request; February 19, 2018. This is an application for a specific exemption to authorize the use of Sulfoxaflor (Transform WG Insecticide EPA Reg. No. 62719-625) to control tarnished plant bug in cotton.

(1) *Identity of contact persons.*

(i) Tennessee Department of Agriculture

John Ewell, Product Registration and Insurance Supervisor
Regulatory Services, Tennessee Department of Agriculture
Ellington Agricultural Center, P.O. Box 40627
Nashville, TN 37204
Office: (615) 837-5340
Fax: (615) 837-5335
Email: john.ewell@tn.gov

Kathy Booker, Pesticide Administrator
Regulatory Services, Tennessee Department of Agriculture
Ellington Agricultural Center, P.O. Box 40627
Nashville, TN 37204
Office: (615) 837-5133
Fax: (615) 837-5335
Email: kathy.booker@TN.gov

(ii) University and registrants contacts:

Scott D. Stewart, Professor
Department of Entomology & Plant Pathology
West Tennessee Research and Education Center
605 Airways Blvd
Jackson, TN 38301
Office: 731-425-4709
Cell: 731-267-6085
Email: sdstewart@utk.edu

Tami Jones-Jefferson
U.S. Regulatory Leader, U.S. Regulatory & Government Affairs – Crop Protection
Dow AgroSciences
9330 Zionsville Road
Indianapolis IN, 46268
Tel: (317) 337-3574
Email: tjjonesjefferson@dow.com

Jamey Thomas
US Regulatory Manager
Dow AgroSciences
9330 Zionsville Road
Indianapolis, IN. 46268
Office: (317) 337-4138
Email: jdthomas@dow.com

(2) *Description of the pesticide.*

Common chemical name (active ingredient): Sulfoxaflor
Brand name: Transform WG (EPA Reg. No. 62719-625)
Formulation: 50WP
Manufacturer: Dow AgroSciences

(A) A confidential statement of formula.

A confidential statement of formula has been previously submitted to EPA with the Section 3 registration package for Transform WG (GF2372, active ingredient sulfoxaflor). Transform WG is a WDG formulation of the active ingredient sulfoxaflor.

(B) Complete labeling to be used in connection with the proposed exemption use.

The proposed label is included in this submission as Attachment A.

(3) Description of the proposed use. The application shall identify all of the following:

(i) Sites to be treated, including their locations within the State:

The insecticide will be restricted to use on cotton fields within the state of Tennessee for the purpose of controlling the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois). Historically, almost all cotton has been produced in the counties of Dyer, Lauderdale, Shelby, Tipton, Carroll, Chester, Crockett, Fayette, Gibson, Hardeman, Haywood, Henderson, McNairy, Madison, Giles and Lincoln (Attachment B, USDA NASS 2016 County Estimates for Tennessee, https://www.nass.usda.gov/Statistics_by_State/Tennessee/Publications/County_Estimates/Cotton16_TN.pdf).

(ii) The method of application:

Foliarly applied by air or ground

(iii) The rate of application in terms of active ingredient and product:

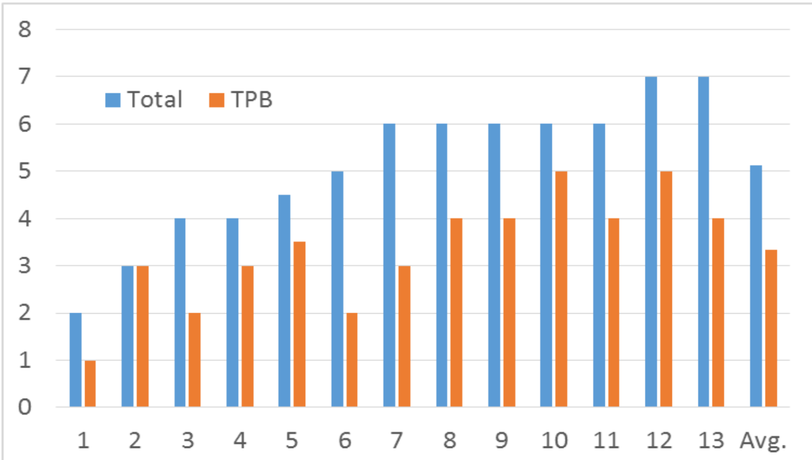
1.5-2.25 oz product/acre (0.047-0.071 lb AI/acre). Annual use will not exceed 0.266 lbs active ingredient per acre (8.5 oz product/acre).

(iv) The maximum number of applications:

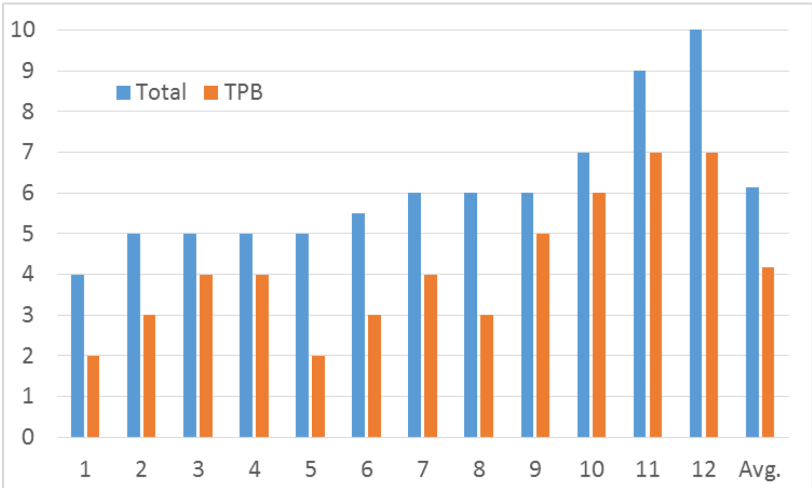
Four applications per acre per year

(v) The total acreage or other appropriate unit proposed to be treated:

The National Cotton Council's annual Cotton Planting Intentions survey estimates that Tennessee will plant 350,000 acres in 2018 (http://www.cotton.org/econ/reports/intentions.cfm). This would represent about a 2% increase compared with 2017. However, current economics and grower comments indicate that actual acres planted could be as high as 380,000 in 2018. Tennessee has the potential need to treat 285,000 acres (75%) of this acreage with sulfoxaflor for control of tarnished plant bug. This assessment is based on estimates of the IPM Extension Specialist (Stewart), agricultural extension agents, and selected consultants that 50-75% of these acres could experience serious Lygus infestations requiring three or more applications of insecticide, and it is these situations where Transform WG is most needed. During recent years, three or more applications specifically targeting tarnished plant bug are needed on a majority of the acres (e.g., Fig. 1).



Consultant Identifier



Consultant Identifier

Figure 1. Survey results from 2014 (bottom) and 2015 (top) of independent crop consultants in West Tennessee showing individual responses and the average (Avg.) number of foliar insecticide applications made per acre and the number specifically targeting tarnished plant bug (TPB).

(vi) The total amount of pesticide proposed to be used in terms of both active ingredient and product:

Tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), infestations may cause economic losses on all acres, but emergency use will be restricted to 285,000 acres in Tennessee during 2018. No more than four applications, and likely two or less, would be required to reduce the impact of this pest. Seasonal use restrictions prohibit more than four applications and 8.5 oz of total product use per acre (0.266 lb ai/acre). Thus, the maximum amount of insecticide that could be applied is 151,406 lb formulated product or 75,703 lb active ingredient.

(vii) All applicable restrictions and requirements concerning the proposed use which may not appear on labeling:

Refer to the Transform® WG container label for first aid, precautionary statements, directions for use and conditions of sale and warranty information. It is a violation of federal law to use this product in a manner that is inconsistent with all applicable label directions, restrictions and precautions found in the container label and this supplemental label. Both the container label and this supplemental section 18 quarantine exemption label must be in the possession of the user at the time of application.

Applicable restrictions and requirements concerning the proposed use and the qualifications of applicators using Transform® WG are as follows:

- Pre-harvest Interval: Do not apply within 14 days of harvest.
- Minimum Treatment Interval: Do not make applications less than 5 days apart.
- Do not make more than four applications per acre per season.
- Do not make more than two applications during the bloom period.
- Do not apply more than a total of 8.5 oz. of Transform WG (0.266 lb AI of sulfoxaflor) per acre per year.
- Label will include a pollinator advisory statement including but not limited to the following:
    - Advisory Pollinator Statement: Treat in accordance with local economic thresholds where populations are equal to or exceed 15 insects per 100 sweeps or 3 per 5 row feet on a drop cloth. Consult your Dow AgroSciences representative, cooperative extension service, certified crop advisor or state agricultural experiment station for any additional local use recommendations for your area.

(viii) The duration of the proposed use:

June - September of the 2018 cotton growing season

(ix) Earliest possible harvest dates:

September 15, 2018

(4) Alternative methods of control. The application shall contain: (i) A detailed explanation of why the pesticide(s) currently registered for the particular use proposed in the application is not available in adequate supplies and/or effective to the degree needed to control the emergency.

Insecticide Resistance: Pyrethroids

Presently, numerous insecticides are recommended against tarnished plant bug, but varying levels of resistance has been documented to nearly every class of these compounds among Midsouthern (Arkansas, Louisiana, Mississippi, Tennessee) populations of this insect. Populations have demonstrated resistance to pyrethroids (Snodgrass 1996, Snodgrass and Scott 2000) since the mid-1990s. Currently, none of the pyrethroids are recommended for tarnished plant bug control in the Tennessee because resistance to this class has become widespread and field experiments show poor control. A summary of all trials conducted at the Delta Research and Extension Center in Stoneville Mississippi from 2004 to 2010 revealed that control with the pyrethroids ranged from 0 to 47% control. In general, bifenthrin (ex. Brigade) showed better activity against plant bugs than other pyrethroids, but control was still less than adequate (Figure 2). In Tennessee, data from multiple insecticide efficacy trials are published on the internet at http://www.utextension.utk.edu/fieldCrops/MultiState/MultiState.htm. In recent years, these trials show applications of synthetic pyrethroids provide less than 30% control of tarnished plant bugs, which is inadequate against even moderate populations. Please see examples in figures 2 and 3 or refer to other data published online.

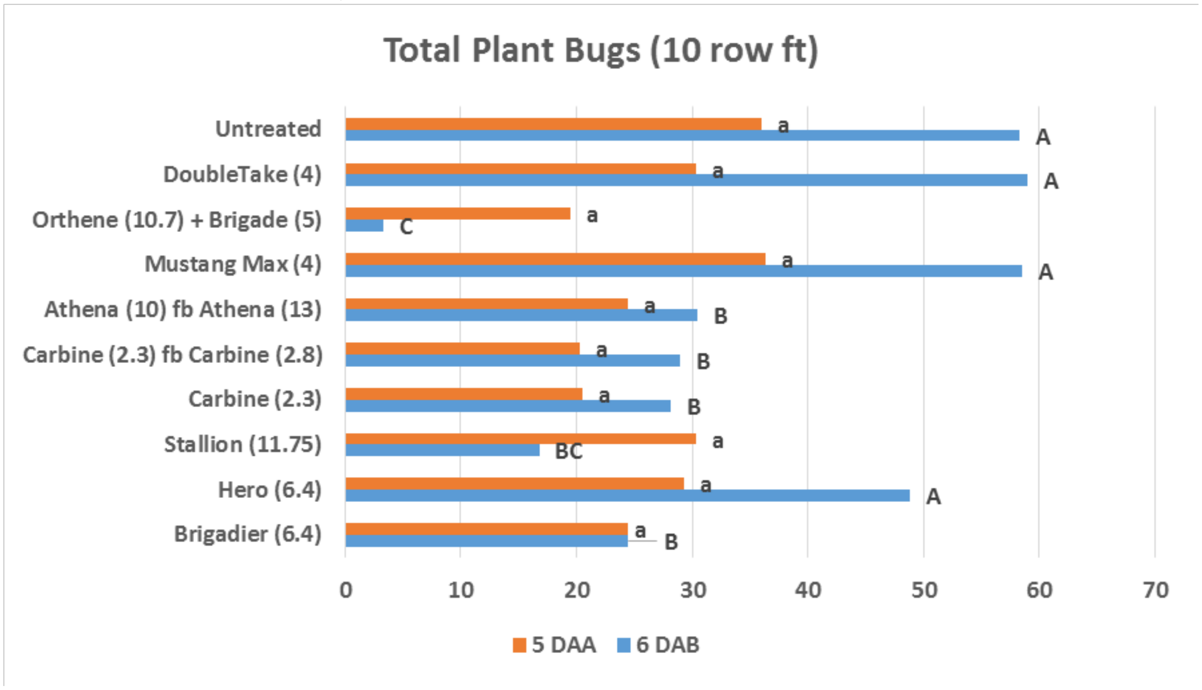


Figure 2. An experiment done in Tennessee during 2014 showing inadequate control of tarnished plant bugs with pyrethroid insecticides including DoubleTake (bifenthrin + diflubenzuron), Mustang Max, and Hero. It also shows the inadequacy of other insecticide classes such (e.g., Athena, Carbine, Brigadier). Ratings are shown for 5 and 6 days after the first and second application, respectively (α = 0.05).

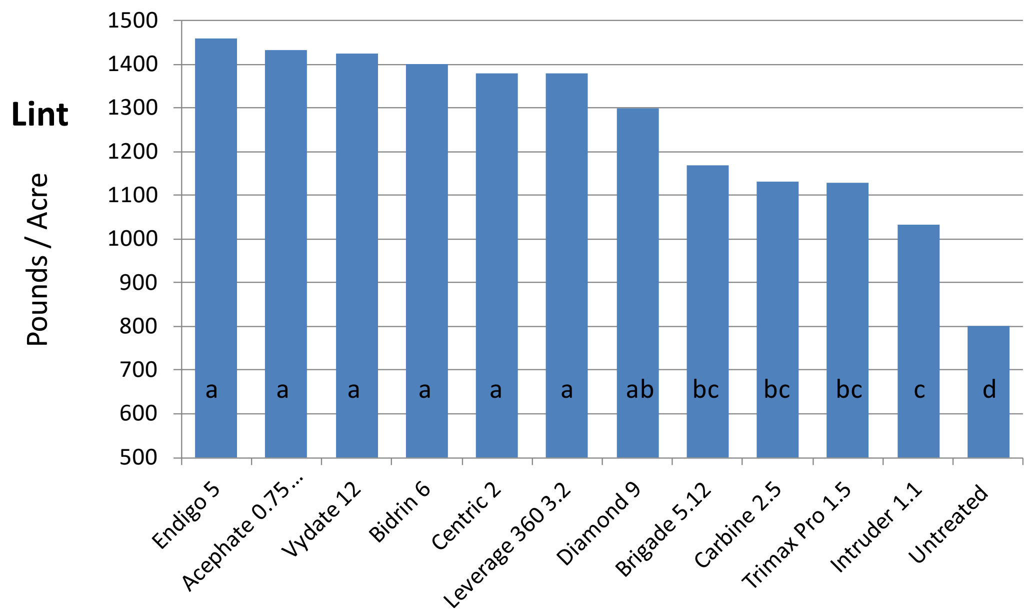


Figure 3. Yield data from a season long cotton experiment performed in west Tennessee during 2010 against tarnished plant bug and stink bug infestation on Bt cotton (Madison Co.). Data do not include sulfoxaflor but show the relative inactivity of Brigade (bifenthrin), Carbine (flonicamid), Trimax Pro (imidacloprid) and Intruder (acetamiprid); resulting in a statically significant yield loss ranging from 19 - 29% after five applications of each compound (P < 0.05). Use rate is indicated on the x-axis (oz product/acre except acephate which is lb ai/acre).

Insecticide Resistance: Organophosphates and Carbamates

More recently, resistance has been documented to several organophosphates (Snodgrass and Gore 2007, Snodgrass et al. 2009). Acephate has been the most widely used and effective insecticide for control of plant bugs in cotton but efficacy continues to decrease in much of the Mid-South. For the purpose of measuring tarnished plant bug resistance to organophosphates, acephate has been used in bioassays to represent the entire class because it is the most utilized for field control. For the most part, populations that show greater than 3-fold levels of resistance to acephate also have high levels of resistance to dicrotophos (Fig. 4). Figure 4 shows the resistance ratios (gray bars) for Baythroid (pyrethroid), Bidrin (OP), Orthene (OP), and Vydate CL-V (carbamate) for tarnished plant bugs. This particular population shows high levels of cross resistance to all classes of insecticides evaluated. The black bars show percent mortality of tarnished plant bugs caged on cotton plants sprayed with field use rates of each of the insecticides. In all cases except Vydate, the highest labeled rate was used. None of the insecticides provided greater than 48% mortality at field use rates. Additionally, preliminary research suggests that there are multiple mechanisms of resistance to the OP's. There appears to be populations with target site insensitivity and metabolic resistance. Most of the plant bug populations across the Mississippi River Delta express target site insensitivity, which confers cross resistance to the other organophosphates and carbamates. Populations that only have metabolic resistance do not always exhibit cross resistance with other insecticides and the cross resistance appears to be linked to the specific enzymes involved. Although not tested, a similar situation likely exists in Tennessee. Vydate had sometimes perform adequately in Tennessee at rates at or above 12 oz/acre (e.g., Fig. 3), but other times provides inadequate control when used by itself or as a tank mix partner at reduced rates, similar as to reported in other states. Regardless, DuPont has reported a serious breakdown at the plant where Vydate is manufactured, and it appears this insecticide will only be available in limited quantities if at all.

In the Mid-South, field efficacy with both acephate and dicrotophos has declined in recent years. Table 1 provides a summary of results from insecticide screening trials conducted by Mississippi State University personnel at various locations across the Mississippi Delta from 2005 through 2010. In 2005, acephate and dicrotophos provided 84.0 and 79.3 percent control, respectively. By 2010, control declined to 45.8 and 28.2 percent control, respectively, for these insecticides. Similar results were seen for yield losses attributed to tarnished plant bugs over that same time period (Table 1). In West Tennessee, resistance monitoring efforts (Table 2) also indicate the presence of resistance to organophosphate insecticides (i.e., acephate or methamidophos) in 9 of 16 populations collected during 2006-2011. Although some OP insecticides such as dicrotophos and acephate still provide adequate control in some circumstances, the level of control is declining and label restrictions and resistance management guidelines limit their utility. Tank mixing with other modes of action is typically recommended to achieve adequate control when severe infestations of tarnished plant bug are encountered.

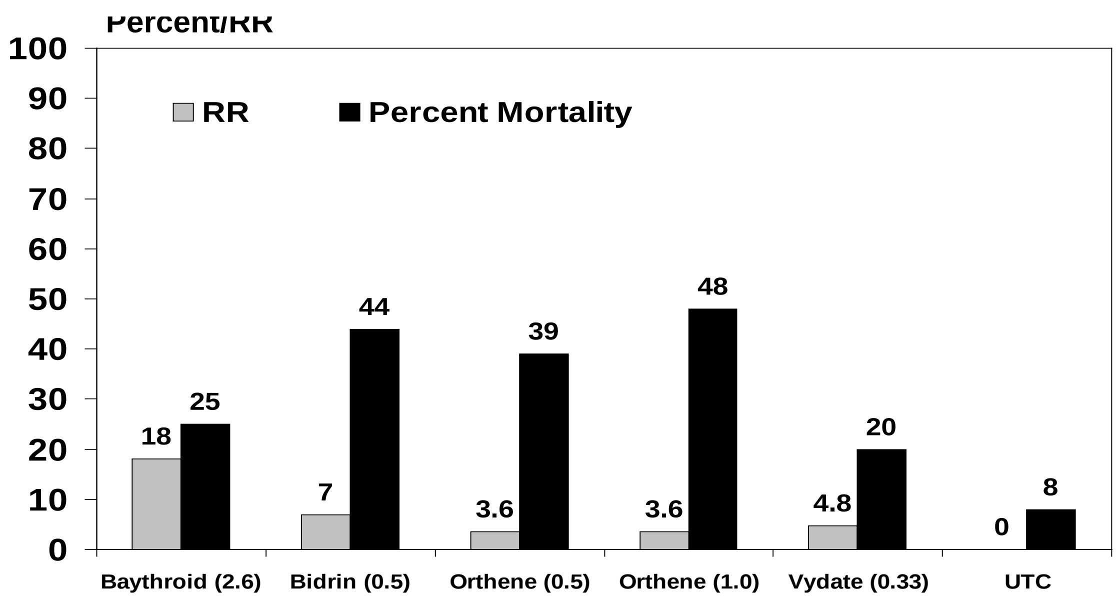


Figure 4. Resistance ratios and control of Lygus with multiple classes of insecticides (AR, LA and MS Delta).

With these levels of control, growers commonly experience field control failures with all of the organophosphates currently labeled for tarnished plant bug control in most delta environments of the Mississippi River and adjacent counties. In West Tennessee, organophosphates are usually applied in a tank mix with another class of insecticide.

Table 1. Average (Standard Error) percent control and yield for Acephate and Dicrotophos from trials conducted in Stoneville, MS from 2005 to 2010 and percent yield reductions compared to 2005.

Year	Acephate % Control	Acephate Yield (Lint/A)	Acephate % Yield Reduction	Dicrotophos % Control	Dicrotophos Yield (Lint/A)	Dicrotophos % Yield Reduction
2005	84.0 (5.0)	1342 (47.4)	---	79.3 (5.8)	1374 (78.6)	---
2006	81.7 (3.8)	1213 (131.3)	9.6	83.3 (3.5)	1149 (129.8)	16
2007	83.5 (3.7)	NA	NA	86.0 (2.6)	---	---
2008	71.6 (2.7)	946 (60.5)	29.5	67.0 (3.1)	936 (93.4)	31.9
2009	55.8 (5.7)	676 (92.6)	49.7	---	---	---
2010	45.8 (2.3)	984	26.6	28.2 (4.3)	970 (77.0)	29.4
P	<0.01	<0.01		<0.01	<0.01	

Table 2. Summary of acephate or Monitor (methamidophos) resistance assays for Lygus collected from west Tennessee. Bolded numbers indicate populations that exceeded predefined resistance threshold (< 75% mortality with a discriminating dose of methamidophos or an LC50 value for acephate > 7.5).

Year	Collection Site (County)	Discriminating Dose (% Mortality) Methamidophos	LC50 ug Acephate
2006	Haywood*	86	---
	Lauderdale*	90	---
	Madison*	98	
	Gibson*	98	---
	Crockett	**60**	4.92
	Dyer	86	
2007	Haywood*	**72**	7.22
	Lake*	88	---
	Madison*	**68**	**9.62**
	Dyer	96	**10.53**
	Crockett	90	4.89
	Tipton	88	**10.64**
2008	Crockett	---	**11.03**
	Madison	---	**7.82**
	Tipton	---	**9.43**
2011	Madison	---	**10.0**

* Spring or early summer samples (other samples were made late summer).

<u>Insecticide Resistance: Neonicotinoids</u>

The neonicotinoid class of insecticides is recommended for both tarnished plant bug control in Tennessee. The insecticides in this class have historically only shown marginal control of tarnished plant bug following first flower when the most serious Lygus infestations typically occur. This has especially true of acetamiprid and imidacloprid (e.g., Fig. 3). Acetamiprid (Intruder or Strafer) is rarely tested because its performance is generally too poor to be considered for tarnished plant bug control. Very little acetamiprid is used except as a tank mix partner when aphid infestations are also present.

Among the neonicotinoids, thiamethoxam (Centric) is more active insecticide against tarnished plant bug. However, the University of Tennessee's insect management guidelines for cotton (PB1768, http://www.utcrops.com/cotton/cotton_insects/pubs/PB1768-Cotton.20pdf) does not recommend using this class of chemistry after first flower as part of an overall resistance management plan, and because alternative insecticides or tank mixes often provide better control. This resistance management plan also suggests avoiding the use of premixed insecticides that also contain a neonicotinoid component (e.g., Endigo and Leverage). Seasonal use rate restrictions prevent more than 2-3 applications of thiamethoxam, either as Centric or as the premix Endigo formulation. Table 3 and Figure 5 demonstrate the poor performance of imidacloprid (Trimax Pro, Couraze 4F or Admire Pro) and bifenthrin (Brigade). Table 5 also shows the relatively superior performance of sulfoxaflor (Transform) that is often observed. That value of Transform is further enhanced by observations in Tennessee during 2017 indicating that the tarnished plant bug is developing resistance to neonicotinoids, and this is reinforced by assay data collected in the Mid-South (Parys et al. 2017).

Endigo is a premix of thiamethoxam and lambda-cyhalothrin and, prior to 2012, was a top performing insecticide (e.g., Figure 3). There are now unpublished reports of resistance to thiamethoxam in some populations of tarnished plant bug (source: USDA ARS in Stoneville, MS). Data collected in Tennessee also shows decreased efficacy of Centric or Endigo (e.g., Table 3).

Table 3. An efficacy trial done in Tennessee during 2015 demonstrating the poor performance of Centric (thiamethoxam) and Strafer (acetamiprid). Note that Transform, Orthene + Diamond, and Transform + Diamond were the top yielding treatments in this test.

Description							Total TPB		Total TPB		Total TPB		Total TPB		Lint (lbs/a)	
Rating Date							7/13/2015		7/20/2015		7/27/2015		8/3/2015		10/12/2015	
Trt-Eval Interval							5 DA-A		12 DA-A		6 DA-B		6 DA-C			
Treatment		Formulation		Rate		Appl										
1	Strafer	70	%	3	oz wt/a	ABC	2.5	bcd	5.8	bcd	24.5	ab	12.0	b	1432	cd
2	Strafer	70	%	3.5	oz wt/a	ABC	1.8	cd	10.0	bc	12.0	cd	12.3	b	1466	a-d
3	Strafer	70	%	3	oz wt/a	ABC	3.3	bc	5.3	cd	7.5	d	4.8	c-f	1616	abc
	Diamond	0.8	lb/gal	6	fl oz/a	ABC										
4	Centric	40	%	2	oz wt/a	ABC	4.3	b	7.8	bcd	26.5	ab	9.3	bc	1457	bcd
5	Centric	40	%	2	oz wt/a	ABC	2.0	cd	7.5	bcd	15.5	bc	5.8	bcd	1597	abc
	Diamond	0.8	lb/gal	6	fl oz/a	ABC										
6	Orthene	90	%	1	lb/a	ABC	2.3	bcd	5.8	bcd	7.8	d	2.5	f	1593	abc
7	Orthene	90	%	1	lb/a	ABC	1.0	d	6.0	bcd	8.3	d	2.3	ef	1736	ab
	Diamond	0.8	lb/gal	6	fl oz/a	ABC										
8	Bidrin XP II	5	lb/gal	12	fl oz/a	ABC	3.1	bcd	11.5	ab	10.8	cd	4.5	b-e	1512	a-d
9	Bidrin XP II	5	lb/gal	12	fl oz/a	ABC	2.5	bcd	10.8	abc	9.5	cd	2.3	def	1680	abc
	Diamond	0.8	lb/gal	6	fl oz/a	ABC										
10	Transform	50	%	1.75	oz wt/a	ABC	1.8	cd	2.0	d	10.0	cd	2.0	def	1742	a
11	Transform	50	%	1.75	oz wt/a	ABC	1.0	d	5.5	cd	9.0	cd	3.5	c-f	1696	abc
	Diamond	0.8	lb/gal	6	fl oz/a	ABC										
12	Untreated					A	7.5	a	16.5	a	28.0	a	31.5	a	1279	d
Means followed by same letter do not significantly differ (P=.05, LSD)																

Other Insecticides and Additional Information

There are currently only two other insecticide classes labeled for tarnished plant bug control. The first is flonicamid (Carbine), a pyridine caboxamide. Although this insecticide does show activity against tarnished plant bugs and provides good control of western tarnished plant bug (*Lygus hesperus*), results have not been promising in the Mid-South (Fig. 5A and 5B, Table 4). Its primary use has been cases where cotton aphids are the primary target, as cotton aphids in Tennessee are now resistant to neonicotinoid insecticides. Carbine often provides only 50-60% control of Lygus or less. Please refer to other examples of efficacy trials in Tennessee with Carbine and other previously discussed insecticide classes (linked below).

http://www.utcrops.com/MultiState/Trials/2014/tpb-FMC%20General%20Cotton.pdf
http://www.utcrops.com/MultiState/Trials/2014/tpb-Intruder%20Summary.pdf
http://www.utcrops.com/MultiState/Trials/2013/FMC-Athena-tpb.pdf
http://www.utcrops.com/MultiState/Trials/2013/FMC-General-TPB.pdf
http://www.utcrops.com/MultiState/Trials/2012/TPB%20SkyRaider%20Cotton.pdf
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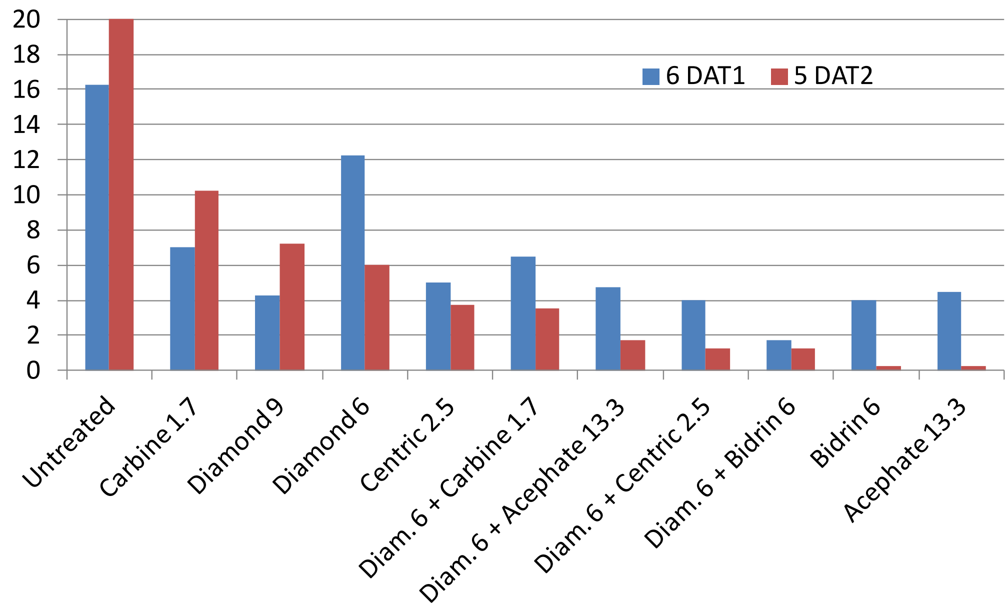

Figure 5A. Numbers of Lygus per 10 row feet following and 6 and 5 days following a first and second application, respectively. Data show how alternative treatments, including Diamond and Carbine, equal to competitive standards (Tennessee, 2010).

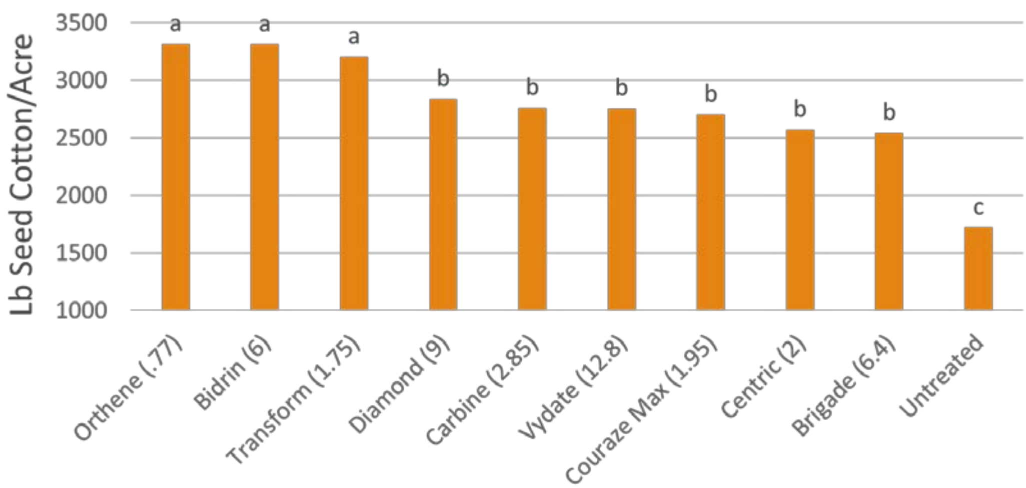

Figure 5B. Yield from a tarnished plant bug efficacy trial done 2017 at Jackson, TN (S.D, Stewart, The University of Tennessee) where two applications of insecticide were applied according to threshold. These data indicate that alternatives such as Diamond, Carbine, Vydate, neonicotinoids (Couraze Max, Centric), and Pyrethroids (e.g., Brigade) are not providing adequate control and yield protection. Use rates are shown on the x-axis (oz product/acre except acephate which is lb ai/acre).

The data below shows the results for an experiment conducted in Stoneville, MS in 2009. The data show the number of nymphs 5 days after the second application of each insecticide in an overall control program. A total of 7 insecticide applications were made to the entire field. Five of those applications were blanket applications applied across the entire field. Carbine did not reduce tarnished plant bug densities below that observed in the non-treated control (Table 6).

Table 4. Results from an experiment conducted in Stoneville, MS in 2009 on tarnished plant bug.

Treatment	Rate	Nymph/5 ft.
Centric	2 oz/A	12.6 B
Bidrin	8 fl oz/A	9.4 B
Acephate	0.75 lb AI/A	5.9 B
Carbine	2.8 oz/A	22.1 A
Non-treated		24.3 A

The other insecticide is novaluron (Diamond), an insect growth regulator. Because novaluron is an insect growth regulator, it only controls the immature stages of tarnished plant bug and has no activity against adults. Field testing of this insecticide generally showed variable results in terms of tarnished plant bug control. In a trial conducted in Sunflower county, MS in 2006, large blocks of cotton on a growers farm were treated with Bidrin at 0.5 lb ai/A, Orthene at 1.0 lb ai/A, Orthene at 1.0 lb ai/A + Diamond at 0.04 lb ai/A, Bidrin at 0.5 lb ai/A + Diamond at 0.04 lb ai/A, and Diamond at 0.06 lb ai/A. Treatments were applied by ground with a high clearance sprayer and all treatments were replicated 4 times. The treatments were applied to an established population and pre-treatment counts averaged 22.6 nymphs per 5 row ft. Two applications were made 7 days apart. Seven days after the second application, tarnished plant bug densities in all of the treatments remained well above the action threshold of 3 bugs per 5 row ft, ranging from 7.2 for Orthene (1.0 lb ai/A) + Diamond (0.04 lb ai/A) to 15.6 nymphs per 5 row ft for Diamond alone (0.06 lb ai/A). Similar results were observed in other trials and by consultants and growers for the first few years that Diamond was commercially available. Other research has shown that Diamond is not very effective on large nymphs. In an experiment conducted in Stoneville, MS in 2007, fifth instar nymphs were exposed to cotton plants treated with a range of field use rates in a spray chamber. The nymphs were allowed to feed on the treated plants until they molted into adults or died (Table 5). The percentage of nymphs that molted into the adult stage ranged from 47.8 at the highest labeled rate to 83.3 at the lowest rate tested. This combined with the rapid growth rate of tarnished plant bug makes timing of the application critical. Adverse weather conditions (rain, high wind, etc.) are common and can delay applications up to a week. In that time frame, susceptible stages of nymphs (1^{st}-3^{rd} Instars) have time to develop to less susceptible stages.

Table 5. Impact of Diamond insecticide (novaluron) on late instar tarnished plant bug nymphs in a controlled experiment in Stoneville, MS.

Treatment	Rate	Percent Adults
UTC	---	96.7 A
Diamond	2	83.3 AB
Diamond	4	60.0 BC
Diamond	6	58.5 C
Diamond	9	69.7 BC
Diamond	12	47.8 C

Over the last several years, we have discovered better ways to use Diamond in an overall Lygus management program. Research in the Mid-South has shown that early preventative applications can help reduce the impact of tarnished plant bugs in cotton. However, the timing of these applications is critical and must target the eggs and early instar stages. The difficulty in using eggs as a trigger is that tarnished plant bugs insert their eggs into plant tissue and are not visible in the field. This combined with the difficulty in controlling late instar nymphs makes managing this pest with Diamond extremely difficult. Using Diamond preventatively in Tennessee, where the intensity and timing of Lygus infestations and timings varies considerably poses a real challenge. Treating large acreage where Lygus populations may not develop into severe infestations can lead to unnecessary insecticide applications. Additionally, control with Diamond against established infestations is typically less than adequate unless two applications are made or tank mixed with other insecticides. Like adult plant bugs, Diamond has no activity on adult stink bugs and this is another reason it generally requires co-application with other insecticides (e.g., Fig, 5B). Further, Diamond is hard on beneficial insect populations and often flares populations of aphids and spider mites (e.g., Fig. 6). Of course, the same is also true of other alternative insecticides, especially when repeatedly sprayed (e.g., Fig. 7).

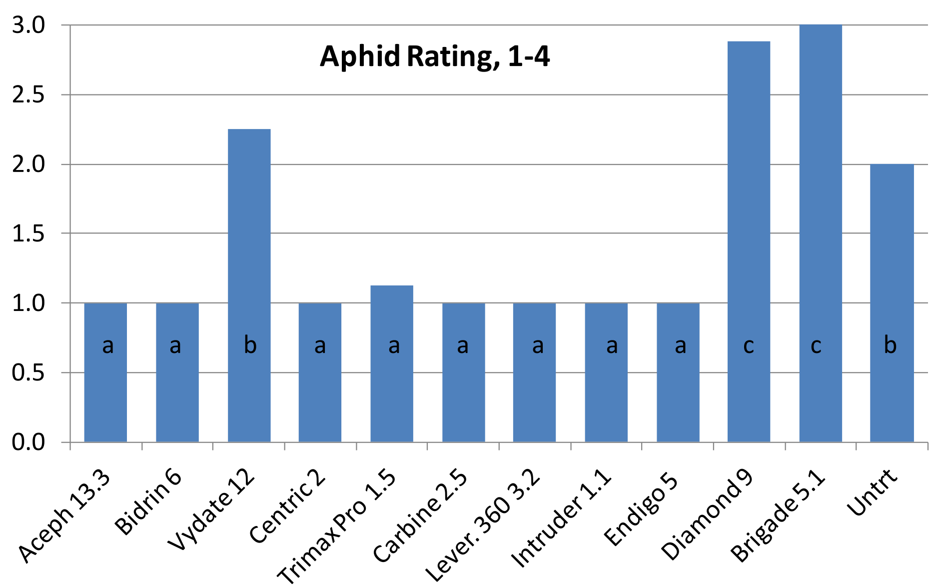

Figure 6. Aphid "flaring" data from a season long cotton experiment performed in West Tennessee during 2010 against tarnished plant bug and stink bug infestations on Bt cotton (Madison Co.). Data show how some competitive standards for tarnished plant bug control such as Vydate (oxamyl), Diamond (novaluron) and synthetic pyrethroids (e.g., Brigade) worsened infestations of secondary pests. Aphid infestations were ranked from 1 (low) to 4 (very high), P < 0.05. Use rate is indicated on the x-axis (oz product/acre).

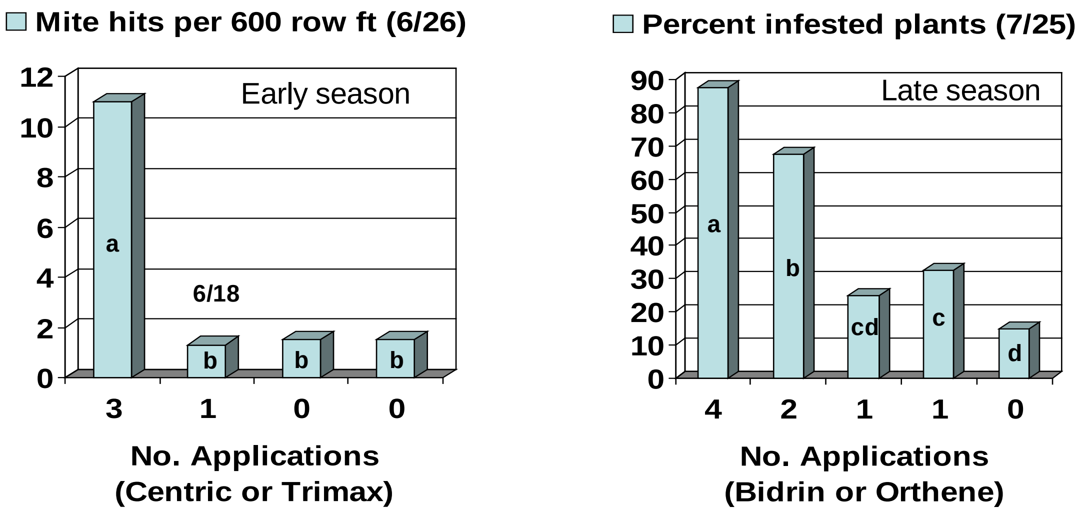

Figure 7. Spider mite "flaring" data from a study evaluating treatment thresholds for tarnished plant bug in West Tennessee during 2007 (Lauderdale Co.). Data show how some competitive standards including neonicotinoids used early season (Centric and imidacloprid such as Trimax, Admire Pro, etc.) or organophosphates used during the flowering period (Bidrin and Orthene), worsened infestations of secondary pests. Insecticides were rotated as indicated where more than one application was made.

In some areas of the Mid-South, tarnished plant bug infestations have reached outbreak levels and become uncontrollable. In Tennessee during 2014 and 2015, some consultants recommended an average of four or more insecticide applications per acre for tarnished plant bug (Fig. 1), and some fields received as many as eight applications for this pest. This has not changed in more recent year. Current trends with insecticide resistance and lack of effective alternative technologies will allow problems with tarnished plant bug management to intensify. Chemical control options that provide consistent efficacy are not available or have significant negative repercussions. Effective Lygus control is a serious, unmet need for Midsouthern cotton growers and one that requires immediate and urgent action. This has now become an emergency situation.

These results have shown that regardless of the registered insecticide, tarnished plant bug populations in the Mid-South have become significantly more difficult to control using common recommended insecticides (Lorenz et al. 2009, Moore et al. 2010). As a result, the numbers of applications and use rates needed to control Lygus have increased. With a novel mode of action and chemical class, sulfoxaflor will successfully control both susceptible and insecticide-resistant populations of tarnished plant bug, thereby improving the overall cotton IPM system. This is a tremendous economic opportunity for cotton growers, and more environmentally-friendly alternative to the sustained frequency of the currently used products. Table 6 shows a study conducted in the Mississippi Delta where all of the currently registered classes of insecticides were used in an overall management program. In this trial, a total of seven applications were made. Each of the insecticides being tested were applied four times, but no more than two times in a row. Ratings of tarnished plant bug control were made after the underlined treatments. These data show that none of the treatment programs provided consistent control of tarnished plant bugs over the entire season. As a result, yields for all of the spray programs were very low compared to state averages in 2010. This experiment shows that an overall tarnished plant bug program is not feasible or economical for producers with the few insecticide classes that are currently labeled in the Mid-South.

Table 6. Evaluation of tarnished plant bug management programs in the Mississippi Delta in 2010.

Treatment	5 DAT 1 % Control	13 DAT 1 % Control	7 DAT 2 % Control	14 DAT 2 % Control	7 DAT 3 % Control	7 DAT 4 % Control	Lint Yield
Vydate 0.33 lb fb Centric 2.5 oz fb <u>Orthene 0.75 lb fb</u> <u>Orthene 0.75 lb fb</u> Diamond 6 oz fb <u>Orthene 0.75 lb fb</u> <u>Orthene 0.75 lb</u>	69	54	50	0	57	0	549
Vydate 0.33 lb fb Centric 2.5 oz fb <u>Diamond 9 oz fb</u> <u>Diamond 9 oz fb</u> Orthene 0.75 lb fb <u>Diamond 9 oz fb</u> <u>Diamond 9 oz</u>	60	72	0	31	62	73	482
Vydate 0.33 lb fb Centric 2.5 oz fb <u>Bidrin 6 oz fb</u> <u>Bidrin 6 oz fb</u> Diamond 6 oz fb <u>Bidrin 6 oz fb</u> <u>Bidrin 6 oz</u>	53	36	0	0	38	0	343
Vydate 0.33 lb fb Centric 2.5 oz fb <u>Vydate 10 oz fb</u> <u>Vydate 10 oz fb</u> Diamond 6 oz fb <u>Vydate 10 oz fb</u> <u>Vydate 10 oz</u>	31	0	75	0	72	0	343
Vydate 0.33 lb fb Centric 2.5 oz fb <u>Centric 2 oz fb</u> <u>Centric 2 oz fb</u> Diamond 6 oz fb <u>Centric 2 oz fb</u> <u>Centric 2 oz</u>	21	16	0	0	72	0	405
Vydate 0.33 lb fb Centric 2.5 oz fb <u>Endigo 5 oz fb</u> <u>Endigo 5 oz fb</u> Diamond 6 oz fb <u>Endigo 5 oz fb</u> <u>Endigo 5 oz</u>	19	12	0	0	26	67	567
Vydate 0.33 lb fb Centric 2.5 oz fb	0	0	0	0	31	23	358

Trimax Pro 1.5 oz fb Trimax Pro 1.5 oz fb Diamond 6 oz fb Trimax Pro 1.5 oz fb Trimax Pro 1.5 oz							
Vydate 0.33 lb fb Centric 2.5 oz fb Carbine 2.5 oz fb Carbine 2.5 oz fb Diamond 6 oz fb Carbine 2.5 oz fb Carbine 2.5 oz	0	40	0	0	18	0	405
Vydate 0.33 lb fb Centric 2.5 oz fb Leverage 360 3.2 oz fb Leverage 360 3.2 oz fb Diamond 6 oz fb Leverage 360 3.2 oz fb Leverage 360 3.2 oz	0	0	0	0	15	0	397
Vydate 0.33 lb fb Centric 2.5 oz fb Intruder 1.1 oz fb Intruder 1.1 oz fb Diamond 6 oz fb Intruder 1.1 oz fb Intruder 1.1 oz	0	12	0	0	42	0	372
Vydate 0.33 lb fb Centric 2.5 oz fb Brigade 5.12 oz fb Brigade 5.12 oz fb Diamond 6 oz fb Brigade 5.12 oz fb Brigade 5.12 oz	0	24	0	17	38	0	312
Check	NA	NA	NA	NA	NA	NA	225

*Ratings start after 4th application

(ii) A detailed explanation of why alternative practices, if available, either would not provide adequate control or would not be economically or environmentally feasible.

Several IPM strategies are recommended for controlling tarnished plant bug in cotton (Gore et al. 2008). Non-chemical tactics include area-wide control of non-crop alternate hosts. Proper selection of early-maturing varieties and managing the optimum planting period are being used to produce a rapid fruiting and early maturing crop; thereby reducing the time the crop is susceptible to this pest. Careful timing of insecticide applications based on revised spray action thresholds are used to precisely target populations before they reach outbreak levels. All of these practices are currently in place and are being used by cotton producers. However, these strategies only serve to suppress populations and are not effective as stand-alone practices. Effective chemical control practices are still necessary to provide tarnished plant bug management in cotton. As highlighted above the current situation in Tennessee has produced severe economic burdens on cotton producers. The Midsouthern states have experienced greater reductions in cotton acres compared to other cotton producing regions of the country. The recent increase in cost of tarnished plant bug control is an important reason for this decrease in cotton acres.

Currently, tarnished plant bugs have widespread resistance to the pyrethroids, organophosphates, and carbamates. In the case of the organophosphates, resistance is partially dominant. A recent study by Snodgrass and Gore showed that because the trait is not recessive, resistance levels do not decline during the winter. Also, relevant genetics data suggests that gene flow can occur between populations that are up to approximately 10 miles apart. These factors have contributed to the rapid spread of resistance in much of the Mid-South. Also, this makes predicting where the resistance levels will be highest from year to year extremely difficult. The widespread resistance to pyrethroids, organophosphates, and carbamates renders these insecticides nearly useless for economical cotton production. Over the last ten years, field use rates have more than doubled and control has continued to decline. This has put a tremendous amount of pressure on the neonicotinoid class. Of that class, thiamethoxam is the most effective for tarnished plant bug control. Consequently, 1-4 preflower applications in cotton may target both tarnished plant bugs and cotton aphids. Centric (thiamethoxam) has been the insecticide of choice in this situation because it provides better control of the whole pest complex than other neonicotinoids at that time of the year. The most common rate used at that time of year is 2 oz formulated product per acre (0.05 lbs ai/A). The maximum seasonal use rate for Centric is 5.0 oz (0.125 lb ai thiamethoxam). Therefore, two applications of Centric at 2 oz/A (0.05 lbs ai per acre per application) during the pre-flowering period does not leave enough active ingredient for later applications of either Centric or Endigo (thiamethoxam + lambda-cyhalothrin). As already mentioned, recent evidence now shows decreased efficacy of Centric on tarnished plant bug. The only other labeled insecticides available are Carbine (flonicamid) and Diamond (novaluron). As previously described, Carbine is not a reliable control option for Lygus in the Midsouthern states. Diamond is the only other insecticide available for late season tarnished plant bug control. Diamond is an insect growth regulator that only controls the immature stages. Therefore, Diamond applications are exclusively used with another class of chemistry to control adults. Also, application timing is critical with this insecticide and applications are often sprayed too late to provide the most effective levels of control. Thus, the use of Transform WG will be important for alleviating some of the economic hardships that cotton growers in Tennessee are currently experiencing.

As expected and previously mentioned, the excessive use of some products for tarnished plant bug are now beginning to induce additional pest problems (spider mites and cotton aphids) in some areas. There is a strong correlation between the number of applications targeting tarnished plant bugs and other pests such as cotton aphids and/or spider mites (Figs. 6, 7 and 8). Problems with these secondary pests have subsided this past 3-4 years, much to the credit of using Transform in IPM program. The loss of Transform is of great concern to producers and pest management practitioners. Organophosphate, carbamate and pyrethroid insecticides can impact natural beneficial arthropod populations and flare secondary insects. Acephate is commonly used for Lygus control and can flare aphids, mites, and bollworm populations. Pyrethroid insecticides often flare aphids and mites, as well. By using sulfoxaflor, we expect a reduction in the use of some insecticides, especially acephate, dicrotophos, and oxamyl. The ecological and toxicological profile of sulfoxaflor is considered to be more favorable than the ecological and toxicological profiles of these insecticides. Data indicates that sulfoxaflor is not likely to flare aphids and mites. Therefore, the use of Transform will and has provided significant economic benefits for cotton growers in Tennessee. Furthermore, the use of Transform since 2012 has replaced products that are well known to be more toxic to honeybees therefore increasing the overall safety to honey bees and likely other pollinators (Zhu et al. 2015)

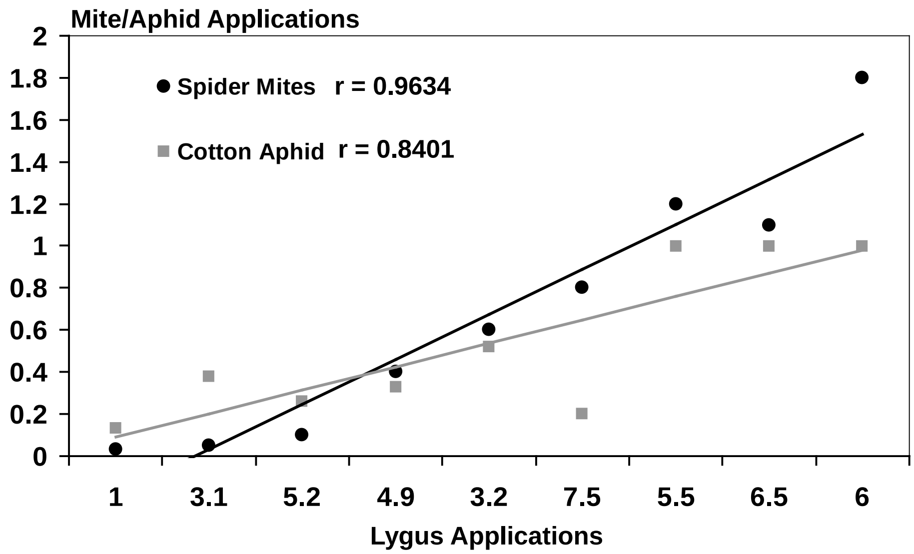

Figure 8. Correlations between Lygus applications and applications for other pests (Mississippi).

(5) *Effectiveness of proposed use. The application shall contain data, a discussion of field trials, or other evidence which provide the basis for the conclusion that the proposed pesticide treatment will be effective in dealing with the emergency.*

Sulfoxaflor (Transform WG™) has been evaluated in laboratory and field trials for the past several years. Recent publications by Babcock et al. (2010) and Zhu et al. (2011) clearly define the biology and biochemistry of sulfoxaflor and demonstrate a novel mode of action against sap feeding insects including those in the order Heteroptera. Insects in the genus *Lygus* are included in this order. Sulfoxaflor-induced mortality was similar between insecticide-resistant and insecticide-susceptible strains of several Homoptera and Heteroptera. No cross-resistance was detected to sulfoxaflor in populations expressing resistance to a broad range of modes of action. These research projects support a novel mode of action for sulfoxaflor including those insecticides with similar chemical structures (neonicotinoids).

Data from several field trials in Tennessee and elsewhere demonstrate the excellent efficacy of sulfoxaflor (Transform) relative to the best alternative insecticides (Figs. 9 and 10, Tables 3, 7, and 7). Other examples are published online at http://www.utcrops.com/MultiState/MultiState.htm. Data collected in 2016 and 2017 continue to indicate that Transform provides excellent control and yield protection against tarnished plant bugs (e.g., Fig. 5B), with only acephate providing as consistent control. In all tests including sulfoxaflor, this product has provided excellent control either as good as or better than the best alternative treatment (typically acephate at the highest labeled rates). Data from other areas of the MidSouth highlight the value of Transform in preserving yield when used in combination or rotation with alternative treatments (e.g., Tables 9).

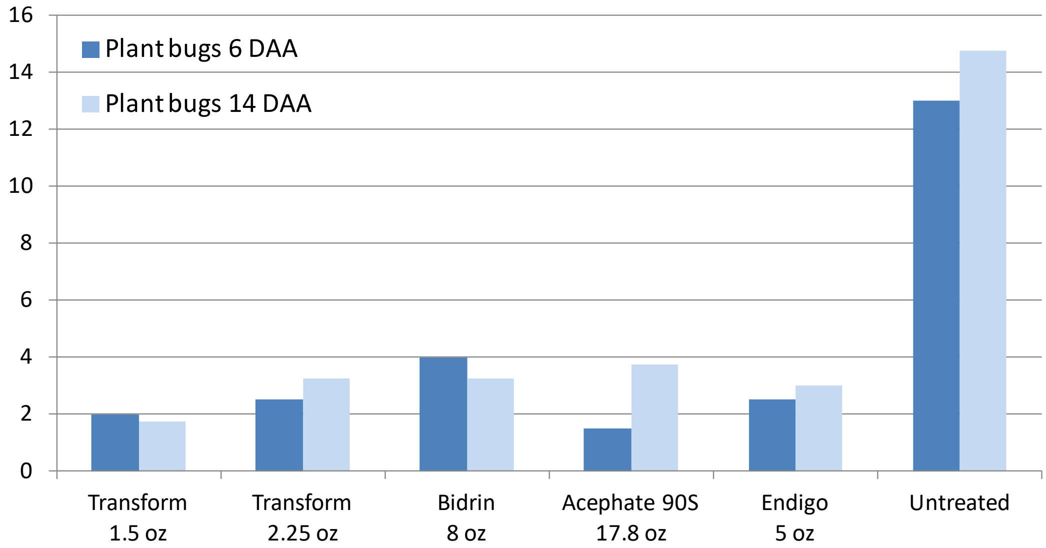

Figure 9. Numbers of Lygus per 10 row feet, showing the relative efficacy of sulfoxaflor vs. competitive standards, Tennessee, 2011.

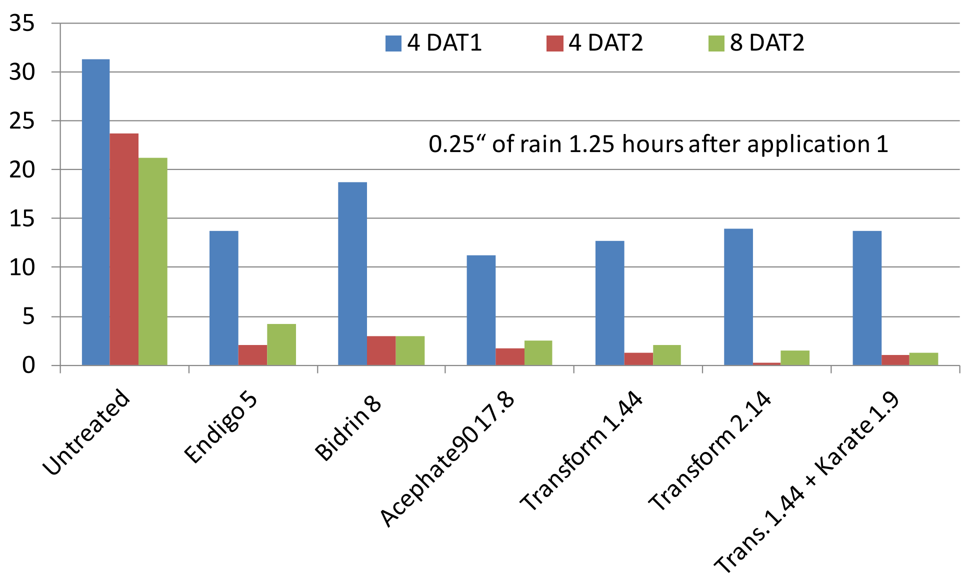

Figure 10. Numbers of Lygus per 10 row feet, showing the relative efficacy of sulfoxaflor vs. competitive standards, Tennessee, 2010.

Table 7. Standard efficacy test comparing Transform to standard insecticides in the Mississippi Delta in 2010.

Treatment	Seasonal Mean TPB Adults and Nymphs

Transform 0.045 lb + Bifenthrin 4.27 oz	13.3 e
Transform 0.067 lb	14.0 de
Transform 0.067 lb + Bifenthrin 4.27 oz	16.8 de
Endigo 0.08	27.5 bc
Bidrin 0.05 lb	35.0 b
Orthene 1 lb	23.0 cd
Untreated	135.8 a
P = 0.0001	

Table 8. Standard efficacy test comparing Transform to standard insecticides in the Mississippi Delta in 2009.

2009 Transform Efficacy Test Compared to Common Standards for Tarnished Plant Bug	
Product	Seasonal Mean TPB Adults and Nymphs
Transform 0.067 lb	8.5 d
Orthene 1 lb	16.3 c
Bifenthrin 6.4 oz	20.3 c
Centric 2.5 oz	33.5 c
Bidrin 0.05 lb	35.0 b
Transform 0.067 lb + Bifenthrin 6.4 oz	8.0 d
Untreated	82.0 a
P = 0.0001	

Table 9. Percent control and yields from a tarnished plant bug program trial conducted in Wayside, MS in 2010.

Treatment	Seasonal Mean No. Lygus	Seasonal Mean Lygus % Control	Lint Yield
Transform 0.045 lb fb Transform 0.045 lb fb Orthene 1 lb fb Transform 0.045fb Transform 0.045	46.8 c	84 a	1266 a
Transform 0.067 lb fb Transform 0.067 lb fb Orthene 1 lb fb Transform 0.067 lb fb Transform 0.067	42.1 c	85 a	1267 a
Orthene 0.5 lb + Diamond 9 oz fb Bidrin 0.5 lb fb Endigo 0.08 lb fb Orthene 0.75 lb + Karate 0.04 lb fb Orthene 1.0 lb	128.3 b	56 b	1019 b
Untreated Check	292.3 a	NA	664 c

[1]Means followed by the same letter are not significantly different (P<0.05).

Although natural enemy populations provide little benefit for tarnished plant bug management, alternative insecticides targeting plant bugs reduce natural enemy populations and "flare" other pests such as twospotted spider mite or cotton aphid. A study conducted in Stoneville, MS in 2013 compared overall management programs. The treatments included cotton grown with all classes except neonicotinoids or sulfoxaflor, all classes except sulfoxaflor, and all available classes. Overall, 1-2 applications were needed for twospotted spider mite in the treatments where sulfoxaflor was not used (Fig. 11). Additionally, the treatments that did not include sulfoxaflor each needed to be sprayed separately for cotton aphid. A portion of this is due to sulfoxaflor control of cotton aphids, but preservation of beneficial insects also contributed. In summary, the use of sulfoxaflor for tarnished plant bug management can reduce the number of insecticide applications targeting other pests because of the lower toxicity to beneficial arthropods. Overall, yields and economic returns were greater where all classes of insecticides were included.

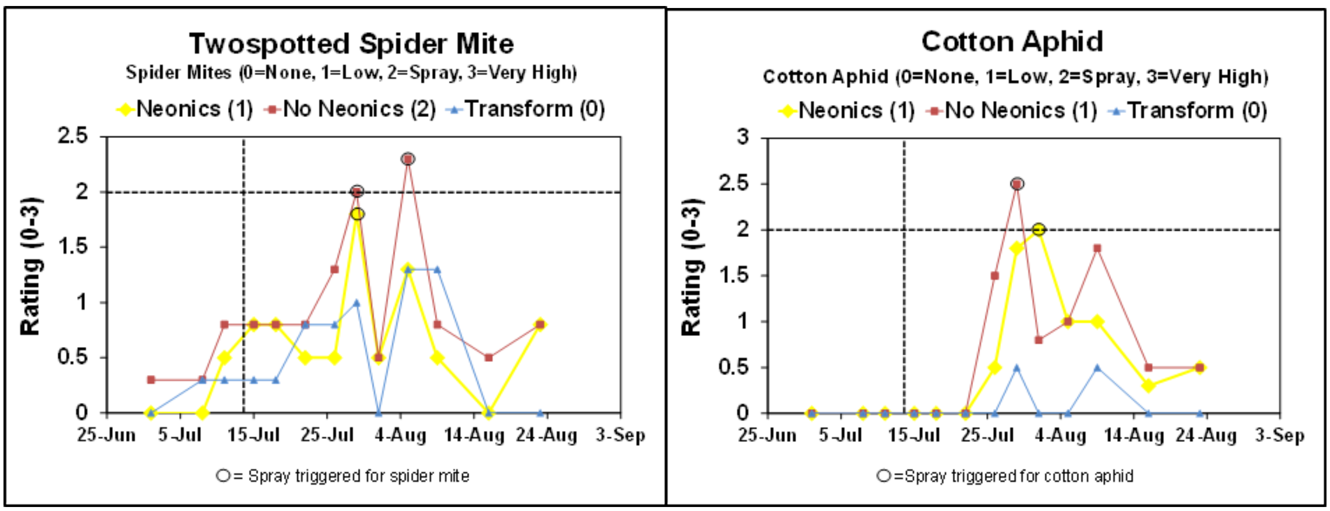

Figure 11. Impact of insecticide use programs for tarnished plant bug management on the number of insecticide sprays for twospotted spider mite and cotton aphid.

From 2014 to 2015 a graduate student at Mississippi State University conducted a study comparing the tarnished plant bug IPM program to a standard approach at multiple planting dates Hills and Delta regions of Mississippi. In the IPM approach, sulfoxaflor was a standard component of the insecticide use strategy. It was also occasionally used in the standard approach when aphids were also present. Overall, the IPM program resulted in greater yields, fewer insecticide applications, and greater economic returns compared to the standard approach (Fig. 12).

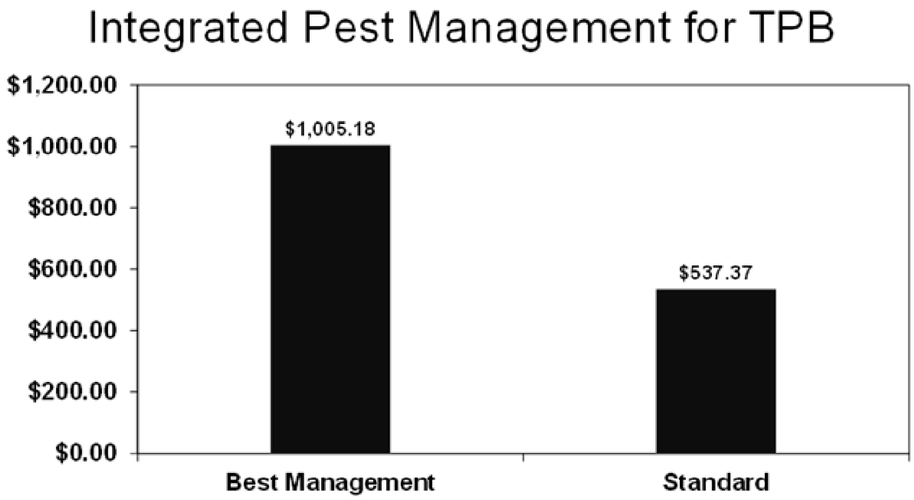

Figure 12. Economic returns for a tarnished plant bug IPM program compared to a Standard approach in Mississippi averaged across 2014 and 2015. The BMP treatments included sulfoxaflor as a foundation of the overall IPM program. It was occasionally used in the standard approach mainly to manage cotton aphid.

Sulfoxaflor (DAS test code GF-2372, proposed trade name Transform™) has been evaluated in laboratory and field trials for the past several years. Recent publications by Babcock et al. (2010) and Zhu et al. (2010) clearly define the biology and biochemistry of sulfoxaflor and demonstrate a novel mode of action against sap feeding insects including those in the order Heteroptera. Insects in the genus Lygus are included in this order. Sulfoxaflor-induced mortality was similar between susceptible and insecticide-resistant strains of several Homoptera and Heteroptera. No cross-resistance was detected to sulfoxaflor in populations expressing resistance to a broad range of modes of action. These research projects support a novel mode of action for sulfoxaflor including those insecticides with similar chemical structures (neonicotinoids).

All available data indicates that sulfoxaflor is an excellent tool for managing tarnished plant bug infestations in Tennessee and Midsouthern cotton IPM programs by improving efficacy, reducing input costs, and increasing yields. This compound has a selective spectrum of activity, has not shown a propensity to flare other pests, can be used as a rotational or tank-mix partner with other chemistries, and has demonstrated value against insecticide-resistant populations. It is likely that sulfoxaflor will be the backbone of chemical control strategies for tarnished plant bug and is critically needed in this emergency situation.

(6) ***Discussion of residues for food uses. If the proposed use is expected to result in residues of the pesticide in or on food, the application shall list the food likely to contain such residues and shall contain an estimate of the maximum amount of the residue likely to result from the proposed use, together with the information on which such estimates are based.***

Acute Assessment

Food consumption information from the USDA 1994-1996 and 1998 Nationwide Continuing Surveys of Food Intake by Individuals (CSFII) and maximum residues from field trials rather than tolerance-level residue estimates were used. It was assumed that 100% of crops covered by the registration request are treated and maximum residue levels from field trials were used.

Drinking water. Two scenarios were modeled, use of sulfoxaflor on non-aquatic row and orchard crops and use of sulfoxaflor on watercress. For the non-aquatic crop scenario, based on the Pesticide Root Zone Model/Exposure Analysis Modeling System (PRZM/EXAMS) and Screening Concentration in Ground Water (SCI-GROW) models, the estimated drinking water concentrations (EDWCs) of sulfoxaflor for acute exposures are 26.4 ppb for surface water and 69.2 ppb for ground water. For chronic exposures, EDWCs are 13.5 ppb for surface water and 69.2 ppb for ground water. For chronic exposures for cancer assessments, EDWCs are 9.3 ppb for surface water and 69.2 ppb for ground water. For the watercress scenario, the EDWCs for surface water are 91.3 ppb after one application, 182.5 ppb after two applications and 273.8 ppb after three applications.

Dietary risk estimates using both sets of EDWCs are below levels of concern. The non-aquatic-crop EDWCs are more representative of the expected exposure profile for the majority of the population. Also, water concentration values are adjusted to take into account the source of the water; the relative amounts of parent sulfoxaflor, X11719474, and X11519540; and the relative liver toxicity of the metabolites as compared to the parent compound.

For acute dietary risk assessment of the general population, the groundwater EDWC is greater than the surface water EDWC and was used in the assessment. The residue profile in groundwater is 60.9 ppb X11719474 and 8.3 ppb X11519540 (totaling 69.2 ppb). Parent sulfoxaflor does not occur in groundwater. The regulatory toxicological endpoint is based on neurotoxicity.

For acute dietary risk assessment of females 13-49, the regulatory endpoint is attributable only to the parent compound; therefore, the surface water EDWC of 9.4 ppb was used for this assessment.

A tolerance of 0.3 ppm for sulfoxaflor on grain sorghum has been established. There is no expectation of residues of sulfoxaflor and its metabolites in animal commodities as a result of the proposed use on sorghum. Thus, animal feeding studies are not needed, and tolerances need not be established for meat, milk, poultry, and eggs.

Drinking water exposures are the driver in the dietary assessment accounting for 100% of the exposures. Exposures through food (sorghum grain and syrup) are zero.

The acute dietary exposure from food and water to sulfoxaflor is 16% of the aPAD for children 1-2 years old and females 13-49 years old, the population groups receiving the greatest exposure.

Chronic Assessment

The same refinements as those used for the acute exposure assessment were used, with two exceptions: (1) average residue levels from crop field trials were used rather than maximum values and (2) average residues from feeding studies, rather than maximum values, were used to derive residue estimates for livestock commodities. It was assumed that 100% of crops are treated and average residue levels from field trials were used.

For chronic dietary risk assessment, the toxicological endpoint is liver effects, for which it is possible to account for the relative toxicities of X11719474 and X11519540 as compared to sulfoxaflor. The groundwater EDWC is greater than the surface water EDWC. The residue profile in groundwater is 60.9 ppb X11719474 and 8.3 ppb X11519540. Adjusting for the relative toxicity results in 18.3 ppb equivalents of X11719474 and 83 ppb X11519540 (totaling 101.3 ppb). The adjusted groundwater EDWC is greater than the surface water EDWC (9.3 ppb) and was used to assess the chronic dietary exposure scenario.

The maximum dietary residue intake via consumption of sorghum commodities would be only a small portion of the RfD (<0.001%) and therefore, should not cause any additional risk to humans via chronic dietary exposure. Consumption of sorghum by sensitive sub-populations such as children and non-nursing infants is essentially zero. Thus, the risk of these subpopulations to chronic dietary exposure to sulfoxaflor used on grain sorghum would be insignificant.

The major contributor to the risk was water (100%). There was no contribution from grain sorghum to the dietary exposure. All other populations under the chronic assessment show risk estimates that are below levels of concern.

Chronic exposure to sulfoxaflor from food and water is 18% of the cPAD for infants, the population group receiving the greatest exposure. There are no residential uses for sulfoxaflor.

Short-term risk. Because there is no short-term residential exposure and chronic dietary exposure has already been assessed, no further assessment of short-term risk is necessary, the chronic dietary risk assessment for evaluating short-term risk for sulfoxaflor is sufficient.

Intermediate-term risk. Intermediate-term risk is assessed based on intermediate-term residential exposure plus chronic dietary exposure. Because there is no residential exposure and chronic dietary exposure has already been assessed, no further assessment of intermediate-term risk is necessary.

Cumulative effects. Sulfoxaflor does not share a common mechanism of toxicity with any other substances, and does not produce a toxic metabolite produced by other substances. Thus, sulfoxaflor does not have a common mechanism of toxicity with other substances.

Cancer. A nonlinear RfD approach is appropriate for assessing cancer risk to sulfoxaflor. This approach will account for all chronic toxicity, including carcinogenicity that could result from exposure to sulfoxaflor. Chronic dietary risk estimates are below levels of concern; therefore, cancer risk is also below levels of concern.

There is a reasonable certainty that no harm will result to the general population, or to infants and children from aggregate exposure to sulfoxaflor as used in this emergency exemption request.

> *The above content (Expected Residues for Food Uses) was prepared by Michael Hare, Ph.D., Texas Department of Agriculture.*

(7) ***Discussion of risk information***

Human Health (Toxicological Profile)

Sulfoxaflor is a member of a new class of insecticides, the sulfoximines. It is an activator of the nicotinic acetylcholine receptor (nAChR) in insects and, to a lesser degree, mammals. The nervous system and liver are the target organs, resulting in developmental toxicity and hepatotoxicity.

Developmental toxicity was observed in rats only. Sulfoxaflor produced skeletal abnormalities likely resulting from skeletal muscle contraction due to activation of the skeletal muscle nAChR in utero. Contraction of the diaphragm, also related to skeletal muscle nAChR activation, prevented normal breathing in neonates and increased mortality. The skeletal abnormalities occurred at high doses while decreased neonatal survival occurred at slightly lower levels.

Sulfoxaflor and its major metabolites produced liver weight and enzyme changes, and tumors in subchronic, chronic and short-term studies. Hepatotoxicity occurred at lower doses in long-term studies compared to short-term studies.

Reproductive effects included an increase in Leydig cell tumors which were not treatment related due to the lack of dose response, the lack of statistical significance for the combined tumors, and the high background rates for this tumor type in F344 rats. The primary effects on male reproductive organs are secondary to the loss of normal testicular function due to the size of the Leydig Cell adenomas. The secondary effects to the male reproductive organs are also not treatment related. It appears that rats are uniquely sensitive to these developmental effects and are unlikely to be relevant to humans.

Clinical indications of neurotoxicity were observed at the highest dose tested in the acute neurotoxicity study in rats. Decreased motor activity was also observed in the mid- and high-dose groups. Since the neurotoxicity was observed only at a very high dose and many of the effects are not consistent with the perturbation of the nicotinic receptor system, it is unlikely that these effects are due to activation of the nAChR.

Tumors have been observed in rat and mouse studies. In rats, there were significant increases in hepatocellular adenomas in the high-dose males. In mice, there were significant increases in hepatocellular adenomas and carcinomas in high dose males. In female mice, there was an increase in carcinomas at the high dose. Liver tumors in mice were treatment-related. Leydig cell tumors were also observed in the high-dose group of male rats, but were not related to treatment. There was also a significant increase in preputial gland tumors in male rats in the high-dose group. Given that the liver tumors are produced by a non-linear mechanism, the Leydig cell tumors were not treatment-related, and the preputial gland tumors only occurred at the high dose in one sex of one species, the evidence of carcinogenicity was weak.

Ecological Toxicity

Sulfoxaflor (N-[methyloxido[1-[6-(trifluoromethyl)-3-pyridinyl]ethyl]-lambda 4-sulfanylidene]) is a new variety of insecticide as a member of the sulfoxamine subclass of neonicotinoid insecticides. It is considered an agonist of the nicotinic acetylcholine receptor and exhibits excitatory responses including tremors, followed by paralysis and mortality in target insects. Sulfoxaflor consists of two diastereomers in a ratio of approximately 50:50 with each diastereomer consisting of two enantiomers. Sulfoxaflor is systemically distributed in plants when applied. The chemical acts through both contact action and ingestion and provides both rapid knockdown (symptoms are typically observed within 1-2 hours of application) and residual control (generally provides from 7 to 21 days of residual control). Incident reports submitted to EPA since approximately 1994 have been tracked via the Incident Data System. Over the 2012 growing season, a Section 18 emergency use was granted for application of sulfoxaflor to cotton in four states (MS, LA, AR, TN). No incident reports have been received in association with the use of sulfoxaflor in this situation.

Sulfoxaflor is classified as practically non-toxic on an acute exposure basis, with 96-h LC_{50} values of >400 mg a.i./L for all three freshwater fish species tested (bluegill, rainbow trout, and common carp). Mortality was 5% or less at the highest test treatments in each of these studies. Treatment-related sublethal effects included discoloration at the highest treatment concentration (100% of fish at 400 mg a.i./L for bluegill) and fish swimming on the bottom (1 fish at 400 mg a.i./L for rainbow trout). No other treatment-related sublethal effects were reported. For an estuarine/marine sheepshead minnow, sulfoxaflor was also practically non-toxic with an LC_{50} of 288 mg a.i./L. Sublethal effects included loss of equilibrium or lying on the bottom of aquaria at 200 and 400 mg a.i./L. The primary degradate of sulfoxaflor is also classified as practically non-toxic to rainbow trout on an acute exposure basis (96-h LC_{50} >500 mg a.i./L).

Adverse effects from chronic exposure to sulfoxaflor were examined with two fish species (fathead minnow and sheepshead minnow) during early life stage toxicity tests. For fathead minnow, the 30-d NOAEC is 5 mg a.i./L based on a 30% reduction in mean fish weight relative to controls at the next highest concentration (LOAEC=10 mg a.i./L). No statistically significant and/or treatment-related effects were reported for hatching success, fry survival and length. For sheepshead minnow, the 30-d NOAEC is 1.3 mg a.i./L based on a statistically significant reduction in mean length (3% relative to controls) at 2.5 mg a.i./L. No statistically significant and/or treatment-related effects were reported for hatching success, fry survival and mean weight.

The acute toxicity of sulfoxaflor was evaluated for one freshwater invertebrate species, the water flea and two saltwater species (mysid shrimp and Eastern oyster). For the water flea, the 48-h EC_{50} is >400 mg a.i./L, the highest concentration tested. For Eastern oyster, new shell growth was significantly reduced at 120 mg a.i./L (75% reduction relative to control). The 96-h EC_{50} for shell growth is 93 mg a.i./L. No mortality occurred at any test concentration. Mysid shrimp are the most acutely sensitive invertebrate species tested with sulfoxaflor based on water column only exposures, with a 96-h LC_{50} of 0.67 mg a.i./L. The primary degradate of sulfoxaflor is also classified as practically non-toxic to the water flea (EC_{50} >240 mg a.i./L).

The chronic effects of sulfoxaflor to the water flea were determined in a semi-static system over a period of 21 days to nominal concentrations of 6.25, 12.5, 25, 50 and 100 mg a.i./L. Adult mortality, reproduction rate (number of young), length of the surviving adults, and days to first brood were used to determine the toxicity endpoints. No treatment-related effects on adult mortality or adult length were observed. The reproduction rate and days to first brood were significantly ($p<0.05$) different in the 100 mg a.i./L test group (40% reduction in mean number of offspring; 35% increase in time to first brood). No significant effects were observed on survival, growth or reproduction at the lower test concentrations. The 21-day NOAEC and LOAEC were determined to be 50 and 100 mg a.i./L, respectively.

The chronic effects of sulfoxaflor to mysid shrimp were determined in a flow-through system over a period of 28 days to nominal concentrations of 0.063, 0.13, 0.25, 0.50 and 1.0 mg a.i./L. Mortality of parent (F_0) and first generation (F_1), reproduction rate of F_0 (number of young), length of the surviving F_0 and F_1, and days to first brood by F_0 were used to determine the toxicity endpoints. Complete F_0 mortality (100%) was observed at the highest test concentration of 1.0

mg a.i./L within 7 days; no treatment-related effects on F_0/F_1 mortality, F_0 reproduction rate, or F_0/F_1 length were observed at the lower test concentrations. The 28-day NOAEC and LOAEC were determined to be 0.11 mg and 0.25 mg a.i./L, respectively.

Sulfoxaflor exhibited relatively low toxicity to aquatic non-vascular plants. The most sensitive aquatic nonvascular plant is the freshwater diatom with a 96-h EC_{50} of 81.2 mg a.i./L. Similarly, sulfoxaflor was not toxic to the freshwater vascular aquatic plant, *Lemna gibba*, up to the limit amount, as indicated by a 7-d EC_{50} for frond count, dry weight and growth rate of >100 mg a.i./L with no significant adverse effects on these endpoints observed at any treatment concentration.

Based on an acute oral LD_{50} of 676 mg a.i./kg bw for bobwhite quail, sulfoxaflor is considered slightly toxic to birds on an acute oral exposure basis. On a subacute, dietary exposure basis, sulfoxaflor is classified as practically nontoxic to birds, with 5-d LC_{50} values of >5620 mg/kg-diet for mallard ducks and bobwhite quail. The NOAEL from these studies is 5620 mg/kg-diet as no treatment related mortality of sublethal effects were observed at any treatment. Similarly, the primary degradate is classified as practically nontoxic to birds on an acute oral exposure basis with a LD_{50} of >2250 mg a.i./kg bw. In two chronic, avian reproductive toxicity studies, the 20-week NOAELs ranged from 200 mg/kg-diet (mallard, highest concentration tested) to 1000 mg/kg-diet (bobwhite quail, highest concentration tested). No treatment-related adverse effects were observed at any test treatment in these studies.

For bees, sulfoxaflor is classified as very highly toxic with acute oral and contact LD_{50} values of 0.05 and 0.13 µg a.i./bee, respectively, for adult honey bees. For larvae, a 7-d oral LD_{50} of >0.2 µg a.i./bee was determined (45% mortality occurred at the highest treatment of 0.2 µg a.i./bee). The primary metabolite of sulfoxaflor is practically non-toxic to the honey bee. This lack of toxicity is consistent with the cyano-substituted neonicotinoids where similar cleavage of the cyanide group appears to eliminate their insecticidal activity. The acute oral toxicity of sulfoxaflor to adult bumble bees (*Bombus terrestris*) is similar to the honey bee; whereas its acute contact toxicity is about 20X less toxic for the bumble bee. Sulfoxaflor did not demonstrate substantial residual toxicity to honey bees exposed via treated and aged alfalfa (i.e., mortality was <15% at maximum application rates).

At the application rates used (3-67% of US maximum), the direct effects of sulfoxaflor on adult forager bee mortality, flight activity and the occurrence of behavioral abnormalities is relatively short-lived, lasting 3 days or less. Direct effects are considered those that result directly from interception of spray droplets or dermal contact with foliar residues. The direct effect of sulfoxaflor on these measures at the maximum application rate in the US is presently not known. When compared to control hives, the effect of sulfoxaflor on honey bee colony strength when applied at 3-32% of the US maximum proposed rate was not apparent in most cases. When compared to hives prior to pesticide application, sulfoxaflor applied to cotton foliage up to the maximum rate proposed in the US resulted in no discernible decline in mean colony strength by 17 days after the first application. Longer-term results were not available from this study nor were concurrent controls included. For managed bees, the primary exposure routes of concern include direct contact with spray droplets, dermal contact with foliar residues, and ingestion through consumption of contaminated pollen, nectar and associated processed food provisions. Exposure of hive bees via contaminated wax is also possible. Exposure of bees through contaminated drinking water is not expected to be nearly as important as exposure through direct contact or pollen and nectar.

In summary, sulfoxaflor is slightly toxic to practically non-toxic to fish and freshwater water aquatic invertebrates on an acute exposure basis. It is also practically non-toxic to aquatic plants (vascular and non-vascular). Sulfoxaflor is highly toxic to saltwater invertebrates on an acute exposure basis. The high toxicity of sulfoxaflor to mysid shrimp and benthic aquatic insects relative to the water flea is consistent with the toxicity profile of other insecticides with similar MOAs. For birds and mammals, sulfoxaflor is classified as moderately toxic to practically non-toxic on an acute exposure basis. The threshold for chronic toxicity (NOAEL) to birds is 200 ppm and that for mammals is 100 ppm in the diet. Sulfoxaflor did not exhibit deleterious effects to terrestrial plants at or above its proposed maximum application rates.

For bees, sulfoxaflor is classified as very highly toxic. However, if this insecticide is strictly used as directed on the Section 18 supplemental label, no significant adverse effects are expected to Louisiana wildlife. Of course, standard precautions to avoid drift and runoff to waterways of the state are warranted. As stated on the Section 3 label, risk to managed bees and native pollinators from contact with pesticide spray or residues can be minimized when applications are made before 7 am or after 7 pm or when the temperature is below 55°F at the site of application.

Environmental Fate

Sulfoxaflor is a systemic insecticide which displays translaminar movement when applied to foliage. Movement of sulfoxaflor within the plant follows the direction of water transport within the plant (i.e., xylem mobile) as indicated by phosphor translocation studies in several plants. Sulfoxaflor is characterized by a water solubility ranging from 550 to 1,380 ppm. Sulfoxaflor has a low potential for volatilization from dry and wet surfaces (vapor pressure= 1.9×10^{-8} torr and Henry's Law constant= 1.2×10^{-11} atm m^3 $mole^{-1}$, respectively at 25 °C). Partitioning coefficient of sulfoxaflor from octanol to water (K_{ow} @ 20 C & pH 7= 6; Log K_{ow} = 0.802) suggests low potential for bioaccumulation. No fish bioconcentration study was provided due to the low K_{ow}, but sulfoxaflor is not expected to bioaccumulate in aquatic systems. Furthermore, sulfoxaflor is not expected to partition into the sediment due to low K_{oc} (7-74 mL/g).

Registrants tests indicate that hydrolysis, and both aqueous and soil photolysis are not expected to be important in sulfoxaflor dissipation in the natural environment. In a hydrolysis study, the parent was shown to be stable in acidic/neutral/alkaline sterilized aqueous buffered solutions (pH values of 5, 7 and 9). In addition, parent chemical as well as its major degradate, were shown to degrade relatively slowly by aqueous photolysis in sterile and natural pond water ($t^{½}$= 261 to >1,000 days). Furthermore, sulfoxaflor was stable to photolysis on soil surfaces. Sulfoxaflor is expected to biodegrade rapidly in aerobic soil (half-lives <1 day). Under aerobic aquatic conditions, biodegradation proceeded at a more moderate rate with half-lives ranging from 37 to 88 days. Under anaerobic soil conditions, the parent compound was metabolized with half-lives of 113 to 120 days while under anaerobic aquatic conditions the chemical was more persistent with half-lives of 103 to 382 days. In contrast to its short-lived parent, the major degradate is expected to be more persistent than its parent in aerobic/anaerobic aquatic systems and some aerobic soils. In other soils, less persistence is expected due to mineralization to CO_2 or the formation of other minor degradates.

In field studies, sulfoxaflor has shown similar vulnerability to aerobic bio-degradation in nine out of ten terrestrial field dissipation studies on bare-ground/cropped plots (half-lives were <2 days in nine cropped/bare soils in CA, FL, ND, ON and TX and was 8 days in one bare ground soil in TX).

The chemical can be characterized by very high to high mobility (Kf_{oc} ranged from 11-72 mL g^{-1}). Rapid soil degradation is expected to limit chemical amounts that may potentially leach and contaminate ground water. Contamination of groundwater by sulfoxaflor will only be expected when excessive rain occurs within a short period (few days) of multiple applications in vulnerable sandy soils. Contamination of surface water by sulfoxaflor is expected to be mainly related to drift and very little due to run-off. This is because drifted sulfoxaflor that reaches aquatic systems is expected to persist while that reaching the soil system is expected to degrade quickly with slight chance for it to run-off.

When sulfoxaflor is applied foliar on growing crops it is intercepted by the crop canopy. Data presented above appear to indicate that sulfoxaflor enters the plant and is incorporated in the plant foliage with only limited degradation. It appears that this is the main source of the insecticide sulfoxaflor that would kill sap sucking insects. This is because washed-off sulfoxaflor, that reaches the soil system, is expected to degrade.

In summary, sulfoxaflor has a low potential for volatilization from dry and wet surfaces. This chemical is characterized by a relatively higher water solubility. Partitioning coefficient of sulfoxaflor from octanol to water suggests low potential for bioaccumulation in aquatic organisms such as fish. Sulfoxaflor is resistant to hydrolysis and photolysis but transforms quickly in soils. In contrast, sulfoxaflor reaching aquatic systems by drift is expected to degrade rather slowly. Partitioning of sulfoxaflor to air is not expected to be important due to the low vapor pressure and Henry's Law constant for sulfoxaflor. Exposure in surface water results from the drifted parent compound, and only minor amounts are expected to run-off only when rainfall and/or irrigation immediately follow application. The use of this insecticide is not expected to adversely impact Louisiana ecosystems when used according to the Section 18 label. Of course, caution is needed to prevent exposure to water systems because of toxicity issues to aquatic invertebrates. As stated on the Section 3 label, this product should never be applied directly to water, to areas where surface water is present or to intertidal areas below the mean water mark. Also, the label includes the statement "Do not contaminate water when disposing of equipment rinsate."

Endangered Species

A list of the endangered species present in this application was obtained from the US Fish and Wildlife Service website (Attachment C, https://ecos.fws.gov/ecp0/reports/species-listed-by-state-report?state=TN&status=listed). None of these species are expected to be impacted by applications of sulfoxaflor to control plant bugs due to very low toxicity to these organisms and/or the fact that they do not occur in the Tennessee cotton ecosystem. This product does adversely affect insects, including bees, and aquatic invertebrates, but the limited exposure to these species should not negatively affect endangered and threatened species when all applications label precautions are followed and preformed.

Resulting Environment from Sulfoxaflor Use

Tennessee's farmscape should experience a reduction in the number of insecticide applications used to control tarnished plant bug. This reduction will be even more important considering that many of those replaced applications will be for organophosphate or carbamate insecticides. The availability of sulfoxaflor on cotton will directly reduce alternative sprays for the target pest, but also reduce the probability of flaring secondary pests such as spider mites and aphids. This can further reduce the number of total insecticide applications on cotton.

The above content (Discussion of Risk Information) was, for the most part, prepared by Michael Hare, Ph.D. (Human Health Effects), David Villarreal, Ph.D. (Ecological Effects), and David Villarreal, Ph.D. (Environmental Fate), all with the Texas Department of Agriculture.

(8) *Coordination with other affected State or Federal agencies.*

The Tennessee Wildlife Resource Agency will receive a copy of this request. Any comments received will be forwarded to the U.S. EPA.

(9) *Notification/support of registrant.*

Dow AgroSciences has been notified of this agency's intent regarding this application and has provided a letter of support (Attachment D). They also provided the copy of a proposed section 18 label with directions for use of this product if this emergency exemption is approved.

(10) *Description of proposed enforcement program.*

The Tennessee Department of Agriculture (TDA) has adequate authorities for enforcing provisions of Section 18 emergency exemptions. TDA will require Dow AgroSciences to prepare Section 18 labeling that complies with TDA and EPA requirements for this emergency use, if approved, to ensure that product distributed for the exemption is properly labeled.

(11) *Repeated uses.*

This is the third consecutive year that the TDA has requested as applied for this specific exemption. A section 18 was previously granted in Tennessee for 2016 and 2017. A section 18 was also granted in 2012.

(b) *Information required for a specific exemption.*

(1) The scientific and common name of the pest or pest complex:

Lygus lineolaris (Palisot de Beauvois), tarnished plant bug

(2) A discussion of the events which brought about the emergency condition:

Tarnished plant bug has become the number one pest in Tennessee. Prior to the mid 1990's, tarnished plant bugs were generally controlled by insecticides directed at other pests during the flowering period of cotton; therefore, economic damage from tarnished plant bugs during flowering was relatively uncommon. However, with > 90% of Midsouthern (Arkansas, Louisiana, Mississippi, Tennessee) cotton now being planted to transgenic cotton expressing one or more toxins derived from *Bacillus thuringiensis* (Bt) (Williams 2008) and the eradication of the boll weevil, *Anthonomus grandis grandis* Boheman (Coleoptera: Curculionidae), many of the foliar applications for other pests during flowering have been eliminated. An increase in federal conservation/wetlands reserve programs, wide scale adoption of conservation tillage systems, and increased diversity of the summer farmscape have created a more favorable environment enhancing populations of tarnished plant bugs. The region has also experienced a substantial reduction in cotton acres. Cotton serves as a sink crop for tarnished plant bugs, and there is an increasingly clear inverse correlation between cotton acres and infestation levels of tarnished plant bugs. The consequence of these changes is that tarnished plant bug has become the dominant, season long pest across this region during the last decade. Because of higher populations which persist longer during the season, control costs and crop losses associated with tarnished plant bugs have increased substantially. Prior to 2004, fewer than two applications per season were typically directed towards this pest. However, applications for tarnished plant bug have been increasing steadily, with private consultants reporting the need to treat for plant bugs an average of 4-7 times per season with individual fields being sprayed eight or more times (Fig. 1). Insecticide applications for secondary pests, specifically spider mites and aphids, were also on the rise. Notably, applications for these secondary pests have decreased once Transform WG became widely used, and yields have increased despite the increasing pest pressure (Tables 10 and 11). These statistics do not fully account for all applications which are, at least in part, targeting tarnished plant bug because bollworm and stink bug applications often include tank mixes with the goal of targeting a pest complex that includes plant bugs.

In addition, an increase in the frequency of chemical control strategies for this pest has intensified selection for resistance. Snodgrass and Gore (2007) has reported resistance to a number of OP's, carbamates, and pyrethroids. Producers were relying heavily on neonicotinoids (thiamethoxam, imidacloprid), but now some populations are showing reduced sensitivity to those products. In addition, the actual seasonal AI/acre of neonicotinoids further restricts product availability. In order to obtain some level of population management, there has been an increase in use rates to the highest labeled doses. Tarnished plant bug management in many Midsouthern fields has degraded to a point where the only option to reduce yield impacts is the co-application of insecticides with different modes of action. As referenced by Luckmann and Metcalf (1982) on the stages of crop protection, cotton producers and pest management practitioners are in crisis phase with tarnished plant bug. The subsequent step is that of the disaster phase which would result in a collapse of the existing pest management system for cotton grown in the Mid-South. Exacerbating the current situation are relatively low commodity prices for 2018 and substantially increased control costs for herbicide-tolerant weeds. Budgets are tight, and even small improvements in yields or reduced control costs for plant bugs might make the difference between a profitable year and a net loss for farmers. Tennessee growers are facing an economic crisis, partly due to the tarnished plant bug because control costs and yield loss have nearly tripled in the last decade. The most expensive insecticide is the one that does not work, and losing Transform WG has imposed a substantial economic burden on Tennessee farmers.

3) A discussion of the anticipated risks to endangered or threatened species, beneficial organisms, or the environment that would be remedied by the proposed use of the pesticide;

See above discussion. Sulfoxaflor is expected to replace alternative products that are used at higher rates and represent greater risk to the environment and beneficial organisms. See Attachment C (Tennessee Endangered and Threatened Species List).

(4) A discussion of the anticipated significant economic loss, together with data and other information supporting the discussion that addresses one or more of the following, as appropriate:

(i) Yield or utilized yield reasonably anticipated in the absence of the emergency and expected losses in quantity due to the emergency;

(ii) The information in paragraph (b) (4) (i) of this section plus prices reasonably anticipated in the absence of the emergency and changes in prices and/or production costs due to the emergency;

(iii) The information in paragraph (b) (4) (ii) of this section plus operating costs reasonably anticipated in the absence of the emergency;

The information below demonstrates the substantial economic impact that plant bugs are having in the Mid-South and Tennessee. These data also demonstrate that since Transform has become available for use in cotton, producers have benefited greatly both in terms of revenue and increased yield protection. Furthermore, during the four year period that Transform has been used, there have been no reports of bee kills associated with this product. Many growers in regions with only moderate resistance levels have also benefitted from the safety toward beneficial insect populations in the field. Overall, Transform has become one of the foundation products in our IPM cotton program.

Table 10. Foliar insecticide costs, yield loss, and the total costs (costs + loss) of managing tarnished plant bug in Tennessee over the past 12 season. Control costs for tarnished plant bugs has nearly tripled in the last decade. These data represent averages across all of Tennessee, and thus, dilute the impact observed in some areas or fields that are more affected by tarnished plant bug.

Year	Yield	Foliar Costs ($/acre)	% Yield Loss	Cost + Loss ($/acre)
2012-2015	928	$31.09	3.20	$52
2008-2011	848	$14.79	2.01	$27
2004-2007	777	$12.22	0.93	$18
% Change	19.4	154.4	244.1	188.9

*Assumes gross $0.70/lb lint value (includes equities and seed check).

Table 11. Yield, yield losses, and the number of insecticide applications for plant bug (PB) and also for secondary pests (e.g., spider mites and cotton aphids) in the Midsouth and Tennessee. In recent years, yield losses caused by plant bugs have almost doubled despite more insecticide applications. Note that since Transform WG was introduced (2012), average yields have increased in the region by over 20% and in Tennessee by about 10%. Also applications and yield loss caused by spider mites and aphids have decreased during this same time frame.

States	Year	Tot Acres	Yield	PB apps	PB loss %	Mite apps	Mite loss %	Aphid apps	Aphid loss %
AR, LA, MS, TN	**2012-2015**	4,618,807	1,052	4.35	4.06	0.50	0.82	0.17	0.05
AR, LA, MS, TN	**2008-2011**	7,797,955	863	3.12	2.72	0.32	0.54	0.20	0.13
	% Change	-40.77	21.9	39.6	49.3	58.8	51.6	-17.4	-61.7
TN	**2012-2015**	1,010,000	928	3.85	3.20	0.17	0.19	0.01	0.01
TN	**2008-2011**	1,460,000	848	1.63	1.70	0.26	0.80	0.05	0.09
	% Change	-30.82	9.4	135.8	88.2	-35.0	-76.3	-76.2	-85.8

Sources:
Cotton Insect Losses, http://www.entomology.msstate.edu/resources/cottoncrop.asp
NASS Yields, http://www.nass.usda.gov/Statistics_by_State/Tennessee/

It is relatively easy to project that the loss of Transform WG for Tennessee cotton producers could result in increased crops losses and more and less effective pesticide applications for plant bugs and secondary pests that could exceed 20% of their net revenue, this in an economic environment where commodity prices already make profitability questionable (and this is true of other major row crops including corn and soybean).

(iv) Any other information explaining the economic consequences of the emergency.

Summary of the Current Situation Facing West Tennessee Producers: Tennessee producers consistently must make foliar insecticide applications to control tarnished plant bugs, which is consistently ranked as the number one cotton insect pest in the state. Despite somewhat moderate plant bug pressure in 2018, growers can expect similar or higher pest populations during the 2018 season. The absence of new products to manage tarnished plant bug has seriously impaired the economic viability of cotton across in parts of Tennessee and much of the Mid-South. Use of currently available products is not economically and environmentally sustainable. Resistance to pyrethroid insecticides, some organophosphates, and now neonicotinoids have left Tennessee with few effective alternative insecticides to control tarnished plant bugs. As previously discussed, resistance and resistance management, the likelihood of flaring secondary pests, label restrictions, and other factors limit the utility of these products. Because sulfoxaflor (Transform WG) is a novel mode of action with no known resistance, it will greatly enhance the producer's ability to manage tarnished plant bugs. Prior to the label being revoked, Transform WG sulfoxaflor had become part of a holistic IPM program for cotton growers in Tennessee.

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